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By Steve Corneli and Steve Kihm

Electricity Policy – the website ElectricityPolicy.com and the newsletter Electricity Daily – together comprise an essential source of information about the forces driving change in the electric power industry.

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In a recent report we wrote for Berkeley Lab's *Future Electric Utility Regulation* series (online at FEUR.lbl.gov), we revisited the concept of natural monopoly and asked whether electric distribution utilities will remain natural monopolies if the capabilities and affordability of distributed energy technologies improve sufficiently. Our basic conclusion: Don't count on it.

The reasons are straightforward. Natural monopolies only exist when cheaper alternatives can't be provided by multiple

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firms. The power sector has already seen cheaper and smaller electric generating technologies and competition from independent power producers (IPPs) erode the utility natural monopoly in generation. In much the same way, continued improvements in the capabilities of distributed energy resources (DERs) to produce, manage and store electricity at ever lower price points would create widespread competitive alternatives to local electric utility delivery service. If and when that happens, the distribution natural monopoly would fade, as a simple matter of economics. This does not mean the distribution system or the grid itself should disappear or that it no longer provides critical value to society. But new regulatory paradigms and business models would be needed to ensure and enhance the benefits the grid can continue to deliver.

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The natural monopoly concept – back to the beginning

Natural monopoly is a concept from economics: It defines a single firm that is technologically able to serve an entire market at a lower cost than multiple firms could. Natural monopoly is associated with extraordinary economies of scale and of scope, often coupled with high fixed costs that serve as barriers to entry. These factors, when present, can allow a single big firm to serve multiple customers at a lower cost than multiple firms serving the same market. Over 100 years ago, Samuel Insull demonstrated that by creating economies of scale and scope – from large boilers and turbines and from connecting such generators with large numbers of customers – a single firm could provide power at a dramatically lower cost than multiple, smaller power companies. Insull's large, integrated power companies are textbook examples of a natural monopoly.

As Insull himself noted, given a *natural* monopoly, policy-makers can provide lower cost power to consumers by awarding a *legal* monopoly to such a single firm, while regulating its prices to only recover its costs. This combination of an exclusive right to serve together with cost-based regulation allowed the utility to achieve the low cost made possible by its economies of scale and scope, but prevented it from charging the above-cost prices that result from an unfettered monopoly.

This policy approach to natural monopoly continues to be recommended by economists today. But it is easy, after 100 years of regulation, to confuse *legal* monopolies with *natural* monopolies. The difference, however, is clear: A natural monopoly, provided it is well-regulated through a legal monopoly, can be more efficient than multiple competing firms. But a legal monopoly, without an underlying natural monopoly, cannot be more efficient than highly competitive markets, no matter how well it is regulated. This is why the regulatory paradigm will need to change if innovation in DER capabilities and cost fully or even partially erodes the distribution utility's natural monopoly.

Regulatory paradigms have changed because of technology and business structures throughout the history of the power sector. For example, at the very beginning of the modern electric utility, policy makers adopted Insull's combination of large exclusive service territories and cost-based regulation, but only after he demonstrated how regulation could allow both consumers and investors to benefit from the economies of scale and scope that exclusive service territories could provide.

This pattern of policies evolving to support innovative technologies and business models did not end with Insull. Subsequent waves of innovation have eroded utilities' natural monopolies in generation and grid operations, leading to both new businesses and new regulatory paradigms. Starting in the 1980s, a period of cost overruns for new large power plants coincided with the emergence of efficient, smaller-scale natural gas turbines. The lower cost and smaller size of these plants allowed them to be developed, financed and operated by multiple, independent firms, at a lower cost than large utility power plants. This gave rise to the widespread conclusion that generation is no longer a natural monopoly, and inspired customers and policy makers to support the lower cost alternatives.

Next, a wave of innovation changed the economies of scope in integrated power system operation. In the final two decades of the 20th century, new computer and data acquisition systems made it possible to coordinate power plant dispatch and transmission management across much larger multi-utility pools, rather than within each vertically-integrated utility. Larger power pools using these technologies demonstrated that the coordination of power plant dispatch and transmission system operation with minute-by-minute changes in electricity demand could be carried out more efficiently on a scale exceeding that of individual vertically integrated firms. As the economies of transferring such operation from vertically integrated utilities to broader, specialized organizations were demonstrated; they became increasingly attractive to utilities and other power sector participants – and to policy makers.

As a result, both of these innovations were followed by major regulatory changes. Electric industry restructuring made generation competitive in 16 states, while the Federal Energy Regulatory Commission required utilities to file Open Access Transmission Tariffs (OATTs) and to consider forming Regional Transmission Operators (RTOs). The new technologies and policies ultimately gave rise to a robust merchant generation/independent power producer (IPP) industry, which, along with power marketers, operates on broad regional transactional platforms made possible by RTOs, Independent System Operators, and the OATT regime throughout much of the United States.

The synergies between these new regulatory and business models is noteworthy: The loss of economies of scale in power plants allowed multiple firms to compete to generate electricity, while the expansion of economies of scale beyond individual utilities gave those firms broad regional platforms on which to compete.

The resulting institutions have arguably increased the efficiency of both operations and capital deployment relative to the earlier systems. Equally important, they left most observers and scholars of the electric industry with the conclusion that the only real remaining natural monopoly in the industry is the delivery function, and the distribution utility in particular. But now, the cost and performance trajectory of key distributed energy resource (DER) technologies are calling even that into question.

Utilities that go to bed as natural monopolies may wake up as providers of public goods.

Distribution: Shifting from a 'natural monopoly' to a 'public good'?

This trajectory raises fundamental questions about key social and economic aspects of the current power system. Utility distribution systems provide critically important social benefits in terms of universal electric service that is safe, reliable, largely affordable and increasingly sustainable. By connecting large numbers of customers and suppliers, distribution systems help create "network economies" – a special kind of economies of scope that generally make it cheaper and better for both suppliers and customers to be connected to a network. Destruction or decay of the network can reduce these network benefits, leaving some customers, and potentially many, worse off.

This problem is even more challenging because these benefits often have what economists refer to as "public good characteristics. Competitive markets can provide ordinary goods efficiently, but often fail to provide public goods. This is because it is easy for parties to enjoy the benefits of these particular types of goods and services without paying for them. As a result, public goods providers find it hard to recover all of their costs in market transactions -- the markets themselves are "missing" due to the inability to charge adequate prices. Because of this, public goods are often provided by governments or through special not-for-profit organizations.[1] If cost-competitive DERs reduce utility revenues more than they reduce utility costs, utilities that go to bed as natural monopolies may wake up as providers of public goods.

DERs: Increasing utility customers' elasticity of demand?

The ability to charge enough to cover costs is not only a problem for public goods. The elasticity of demand also impacts cost recovery even for providers of ordinary

[1] Weimer, David L. and Vining, Aidan R. *Policy Analysis: Concepts and Practice.* 2011. Longman. See pp. 72-76.

goods and services. Demand is elastic if consumption of a particular good falls significantly as the price increases. Inelastic demand means consumption continues despite higher prices – often due to a lack of competitively priced alternatives. Thus, the customers of natural monopolies, which are defined by the lack of competitively priced alternatives, typically have relatively inelastic demand. But as DER cost and performances improve, utility customer demand should become more elastic, due to the availability of affordable alternatives.

This will create a profound shift in an industry that has long been accustomed to inelastic demand. Since Insull's day, regulators have worked to balance rates between levels that are too low for investors or too high for consumers. Highly elastic demand for power will make the first part of this balancing act harder and harder. Approving high cost-based rates will fail to recover utility costs if customers have access to lower cost alternatives for energy and capacity. Instead, higher rates may simply accelerate the shift of customers to competitive DER alternatives.

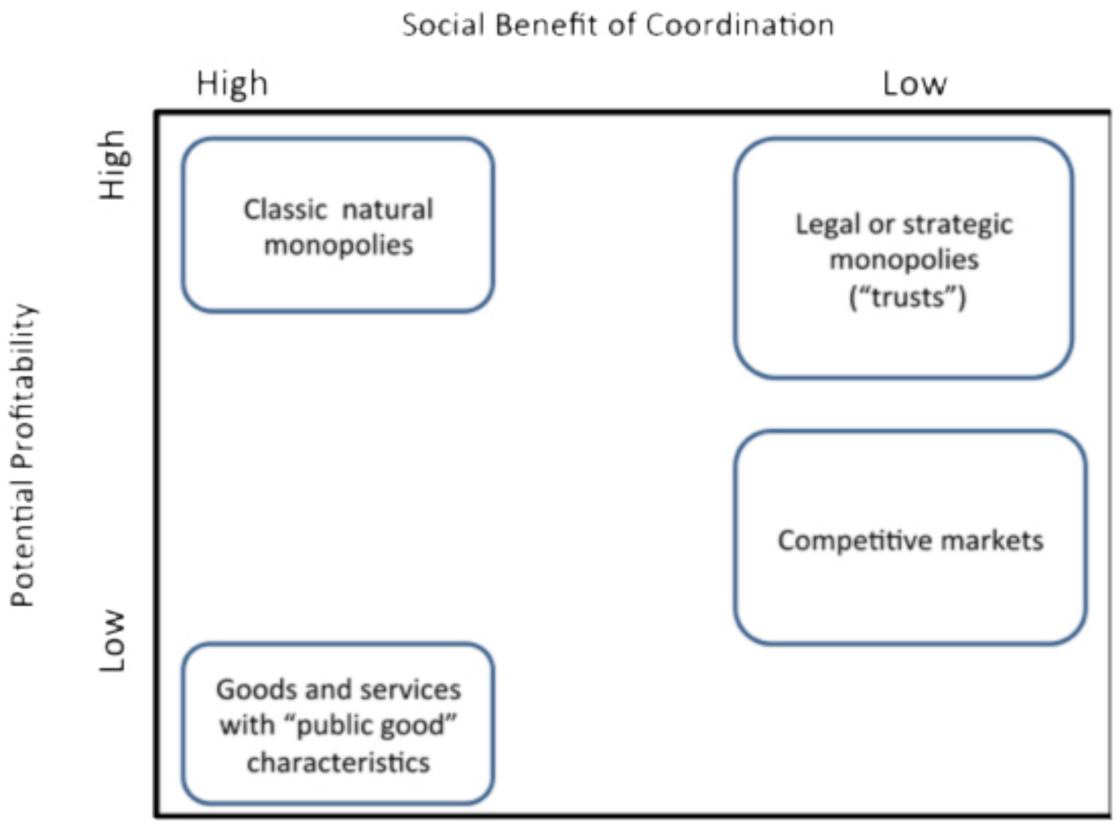

Figure 1 - The Basic PPSB Box

Potential Profitability and Social Benefits (PPSB) Framework. Corneli developed this simple framework as a starting point for evaluating key features of the electric industry and potential policy and regulatory responses. Industry structures that rank high in both dimensions — natural monopolies — are in the upper left corner.

This would make the distribution system, and potentially the grid itself, harder and harder to pay for, even though it continues to provide substantial public benefits. As more elastic demand and less pricing power squeeze utility margins, regulators, investors and utility managers will increasingly find that cost efficiencies and even outright cost reductions offer the best path to cost recovery.

A new framework to assess and evaluate utility and power sector institutions

These insights from the economic concepts of natural monopoly, public goods, network economies and demand elasticity are sobering in terms of the prospects of current utility regulatory and business models. To better understand the combined impact of these and related concerns for the future of key power sector institutions, one of us (Corneli) developed a simple two-dimensional framework that captures all these concepts in a single conceptual tool. We call this the "PPSB box," as shown in **Figure 1**.

The first dimension of this tool is the *potential profitability* (PP) of various business models across various power sector functions, such as generation, transmission, distribution and grid balancing. High PP characterizes technologies and business models that can price well above their costs. Low PP reflects technologies and organizational models for providing goods and services with strong public good characteristics. (Prices are not revealed for public goods because of the missing markets problem.[2]) This full range is seen from today's profitable regulated utilities and IPPs to various non-profit municipal and cooperative utilities and RTOs.

The second dimension represents the *social benefits of coordination* (SBC). High SBC characterizes organizations with strong economies of scope, including network economies. Low SBC organizations are typically competitive firms, with little inter-firm or inter-organization coordination. Today's power sector shows the full range from high SBC, among large RTOs, vertically integrated utilities, and regional reliability coordinators, to very low SBC among IPPs and competitive providers of distributed generation.

Within the PPSB box, strong natural monopolies with both economies of scale and scope are located in the upper left hand corner. Non-profit providers of public good infrastructure that supply a large amount of coordination are found in the lower left hand corner, and competitive firms with medium levels of potential profitability and that do not require high levels of coordination are typically located in the middle-right side of the box. In the power sector, the high SBC coordination function serves as a network platform on which lower SBC competitors do business. We note that this relationship between highly coordinating network providers — typically regulated or provided as a public good — and competing network users is common in other industries, such

[2] Stiglitz, J. and Rosengard, J. 2015. *Economics of the Public Sector*, 4th ed. New York, NY: W. W. Norton & Co.

as air and surface transportation, natural gas pipelines, and the internet.

Insights from the PPSB box

This framework makes it easy to see increasingly competitive and diverse DERs pushing the electric distribution utility further down (reducing potential profitability) in the PPSB box, increasing the need for broader-based funding to support the social benefits of coordination that its network will still enable (see **Figure 2**). By competing with IPPs, DERs will also put a degree of downward pressure on competitive market prices, though those markets may sustain profitability as supply levels adjust to meet demand.

Further, there may be significant synergies

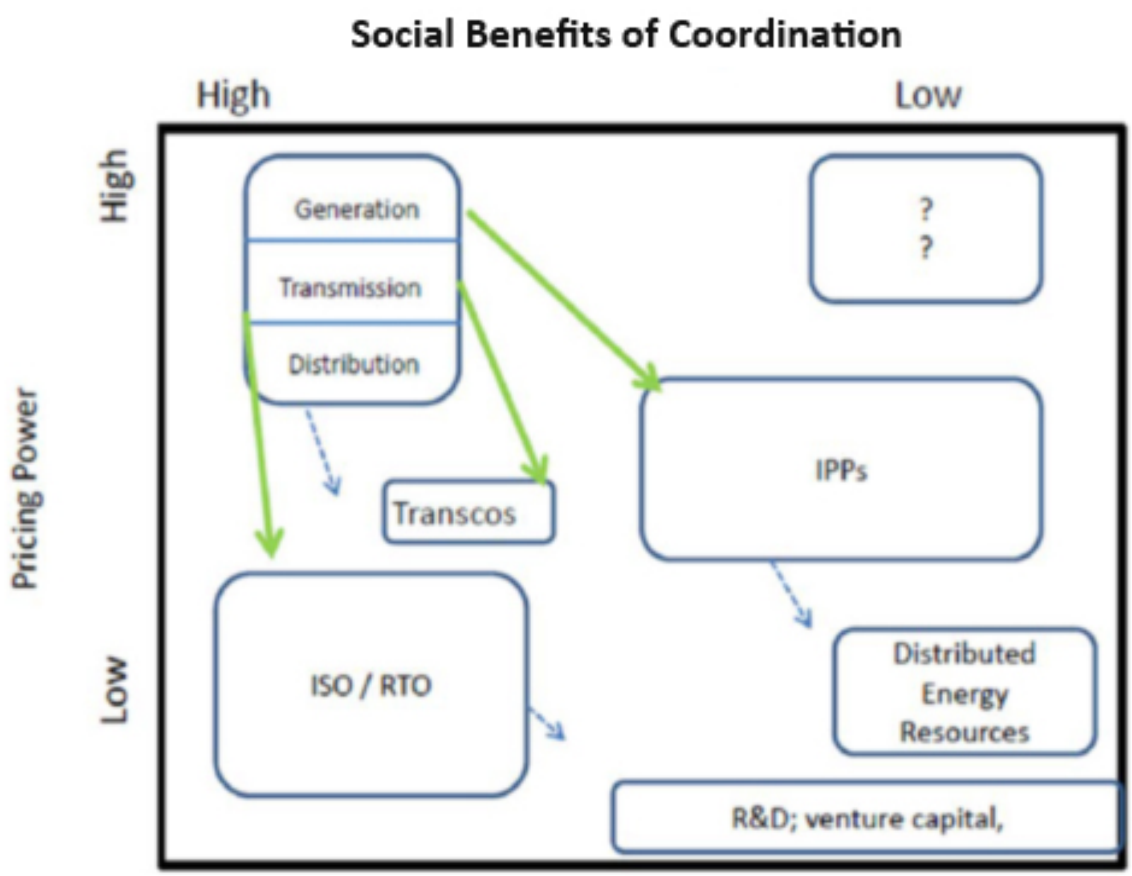

Figure 2 - The Power Sector in the PPSB Box

DERs with continuously improving cost and performance capabilities will reduce the potential profits of distribution companies and other power sector participants (blue arrows). This will further reduce the natural monopoly characteristics of utilities, following the pattern earlier created by competitive generation and regional grid optimization (green arrows). Distribution companies may evolve to host coordination platforms for DERs, much as RTOs do for IPPs.

between DERs and wholesale suppliers, if controllable DERs are able to help avoid negative prices and other market challenges associated with integrating large amounts of variable renewable energy resources.

At the same time, we see increasing benefits from coordination between the grid, the distribution system and consumer-based DERs. This suggests to us that the distribution utility itself could evolve in the same direction as the grid operation function in the late 1990s – towards hosting a coordination platform to support the operation and delivery of DER benefits to customers, the distribution utility itself, and to the broader grid.

While our initial review of natural monopoly, public goods, and increasing demand elasticity painted a gloomy picture for the regulated distribution utility, integration of these issues in the PPSB box suggests a more optimistic pathway for many distribution utilities. The need to enhance cost efficiencies points distribution companies towards greater scale, through mergers or through closer operational coordination. In turn, this larger scale could provide an even more efficient platform for enhanced DER-grid coordination. Finally, optimizing the DER platform should further enhance utilities' ability to manage costs, while increasing the value of grid connectivity to DER customers.

It remains to be seen whether such synergies in cost and value would be sufficient to maintain distribution utilities in the "for profit" middle left of the PPSB box (Figure 1). If not, in a world with abundant DERs and highly elastic demand, society may need to treat the grid as basic "public good" infrastructure, much as roads and airports are treated today.

Conclusion

The PPSB box cannot answer all of the important questions facing power sector decision makers. Will utilities directly manage and optimize DERs for their customers? Or will that coordination task be performed largely by competitive providers using digital optimization technologies that respond to a combination of customer preferences, price signals, weather and system information, and the occasional directive from a utility? Will competitive firms or utilities best support the deployment of DERs? How will distribution planning evolve to find the best mix of technical and customer value from DERs? And, perhaps more important than any of these, can utility ownership of DERs offer utility or consumer cost advantages relative to consumer ownership of DERs? As our Berkeley Lab report shows, we have different views on these questions ourselves.

The PPSB box serves the important role of framing the analysis. It does not itself answer these questions, but it can help regulators, investors, and utility managers do so. If global companies can provide and optimize DERs for consumers at a lower cost than utilities can afford to charge, DER deployment belongs in the competitive markets on the right side of the PPSB box, not the left side. If the function of coordinating DERs is not profitable, but unlocks large amounts of value from DERs for customers, the wholesale grid and the distribution system, that function should be carried out by entities in the lower left side of the box, not by regulated for-profit firms in the middle of the box (left or right side). As we make clear in our Berkeley Lab report, the "right" answers to these questions are likely to vary in different parts of the country and for different utilities.

More broadly, the PPSB box helps us see the potential for improved DERs to put a widespread squeeze on utility profitability and to chart a path for electricity distribution systems and their many benefits to evolve. Finding such a path could become a priority for utility investors, managers and regulators who need to reduce the costs of the distribution system while enhancing its value to all customers. Doing so will entice customers with DERs to remain connected to the distribution system, while contributing to its lower cost and its ability to provide greater benefits to all.

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